222 Growth and Development

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Continual change is the essence of life. The rapid changes in size that we call *growth,* and the rapid changes in form, function and behavior that we call *development,* are the core of pediatrics. A good working knowledge and the skill to evaluate growth and development are necessary in the diagnostic evaluation of any patient. Subtle changes—often the failure of some change or event to occur at an expected time—may constitute the earliest sign of disease. The early recognition of growth failure or maldevelopment may be the discovery that sets in motion the investigations necessary for effective intervention in the management of a patient's problem.

Assessment of Growth

The proper evaluation and use of anthropometric measures such as height, weight, and head circumference must be accorded equal status with other clinical data. The greatest difficulty lies in the definition of *normality.* This is generally done statistically. Unfortunately this often leads to the common error of assuming that the average or median value represents the optimum for a given patient. That this is erroneous is clear if one imagines 100 normal children of the same age but all of different weight. Only 1 child (the median, 50th percentile child), heavier than half the others but lighter than the other 50, would be considered normal, even though this violates the original premise that all the children are normal.

The necessary concept that there is a wide range of normal allows another kind of error, that of accepting as normal for an individual some value that falls within the normal range but is in fact abnormal for the given child. This is compounded by the fact that *to the eye,* and in figures on paper, such abnormality may not be apparent even to the most practiced eye of a skilled physician. For this reason, it is absolutely necessary to plot the parameters of growth on a suitable graphic chart. Plotting the data brings to light even slight departures from the expected path. Small changes such as the failure to gain 1 kilogram in 3 months are at once apparent. Serial data thus plotted constitute the best standard of normality for the individual.

It is well established that the individual grows in a "channel," probably genetically determined, and that such channel is specific for the individual. Departures from this channel, with rare exceptions, occur only in the event of noxious influence (e.g., disease, calorie excess or deficit, or even psychic disorder). When such departures occur, a return to the original channel will be observed if the cause is repaired. In the case of growth failure, for example, this return occurs by "catch-up" growth, which represents the fastest growth rate known. When dealing with a sick child, in the absence of earlier serial data, this "turning the corner" from catch-up growth into a channel that parallels a designated percentile guide is a good, and often the only, means of identifying the channel normal for that child until there has been an opportunity to accumulate sufficient serial data.

The charts in most common use have been based on measurements of populations of presumed normal children. One should have some familiarity with the base data. Is the chart based on "over 200 children living in Boston," or was it derived from a population of Iowa farm children? There is now a group of charts that set a more recent standard, derived from NIH studies covering a wider spectrum of the United States. The Wetzel grid, although never very popular and little used, has the unique property of having been developed on theoretic grounds instead of being a statistical description of a population. This grid plots "developmental level," a parameter related to physique, surface area, and basal metabolic rate, against age. It has been shown to be valid for any population or species. Another type of chart (Tanner) has been developed that depicts the *rate* of growth versus unit of time. This is particularly useful in studying the changing rates of growth that are characteristic of various periods of life and in relating the events of puberty and adolescence to physical growth. It will be referred to later. As it happens, if one adheres to the standard of normality consisting of following a channel (maintaining percentile rank), any of the charts alluded to can serve the purpose, although the percentile ranking may vary with the chart used. All these charts are designed to have increments of measure plotted against time and thus represent achieved status at any given age.

Normal Growth Rates

Humans grow at different rates at different times of life; there are rate differences between the sexes and various tissues have different rates of growth at the same time. Obvious examples are the fact that girls of 13 or 14 are often the same or even greater height than their male peers and then are surpassed in stature by males within a couple of years. The lymphoid structures of a child grow so rapidly that within 6 or 7 years they achieve status far exceeding 100% of adult size and are in fact receding during adolescence when the body as a whole (skeletal, muscle mass, and blood volume) is increasing *in the rate* of growth. Thus a second grader's tonsils may be very large and yet not be *enlarged;* a young child's spleen may become palpable during any infection, and mesenteric adenopathy is ever present in the differential diagnosis of appendicitis in children.

The human head grows so fast that it reaches near adult size in only 6 years. This rapid head growth necessitates birth for humans, unlike other mammalian species, at a time long before walking is possible. Were this not so, the head could not pass the pelvic outlet. Special charts are used to follow this phenomenon. Because the skull is so readily expansible, increasing intracranial pressure may manifest

few other signs; papilledema, for example, may not occur if the sutures are not knit.

Human growth curves are characteristic of the species. After conception, there is a lag phase that soon becomes logarithmic. Term birth occurs during the logarithmic phase so that at birth the child is growing at the rate of 9 to 10 kg/yr. This growth rate declines almost asymptotically, and by the end of the first year growth is proceeding at a much slower pace of 2 to 2.5 kg/yr. This marked reduction of rate can be regarded as the physiologic marker of the end of infancy.

It is notable that major inflections of the growth curve are also associated with signal developmental events, for example, the accomplishment of locomotion and its psychodynamic companion, the first autonomy struggle. Nutritional requirements are high during periods of rapid growth and hence deficiency states are most likely in their wake. Characteristically clinical scurvy, rickets, and iron deficiency anemia arise during the latter half of the first year. Similarly, at the next inflection, the adolescent growth spurt, we find increased vulnerability to depletion of calcium and iron stores and another autonomy struggle, this time involving separation from home and both parents, whereas the first one, the "terrible twos," represented chiefly separation from mother. Awareness of these growth phases and their attendant psychodynamic implications enables the examiner to anticipate patient behavior and facilitates establishment of effective rapport as well as suggesting normal and pathologic phenomena to be searched for.

Stages of Development

It is useful to conceive of developmental periods, each characterized by certain tasks to be accomplished. The failure to accomplish these developmental tasks is evidence of disease, either past or present.

Infancy

At birth the infant is largely a reflex being equipped with primitive reflexes. Some of these, such as the rooting and sucking reflexes, are obviously utilitarian. It is generally true that most of the developmental milestones are first present in reflex form and then are modified as the developing central nervous system achieves peripheral connection through myelinization of the long spinal tracts. For example, the newborn infant has a firm reflex grasp. It requires about 4 months for the child to be able to reach out and seize an object and then this is done only in a gross fashion, using chiefly the ulnar musculature. It will require another 2 months to be able *to release* an object held in the grasp; hence the ability to move an object from one hand to the other marks the middle of the first year. At about 9 to 10 months, thumb and finger apposition come into play, and the child becomes prehensile.

Development follows the principle of cephalo–caudal differentiation as can easily be observed in the child's struggles to seize objects before the hand can be made to do the brain's wishes. Social interplay, a cortical function, is well developed by 6 months when the child can just begin to move objects from hand to hand (shoulder girdle and cervical spine) and cannot yet usefully move the lower extremities (lumbar plexus and associated myotomes). Early speech sounds appear before ambulation is well established.

Evaluation of the very young sick infant is quite difficult because so few signs indicating disease are manifest. The social smile, the earliest sign of interpersonal interaction, appears only after about 4 weeks. Lack of even this rudimentary sign to aid an overall estimate of severity of illness commonly dictates that infants of lesser age be observed under hospital conditions until it becomes clear that no serious disease is present. Acquiring command of one's body is the major task of the first year.

Childhood

Soon after the end of the first year, ambulation is well established. The newfound ability *to leave mother* ushers in the period known to most parents as the "terrible twos." The developmental task of this period is to discover and establish self-identity. For this reason, the child finds it difficult to accede to adult requests. It is essential to be established as an autonomous individual. Therefore the child cannot be agreeable, for if he or she always does the bidding of others, the fact of autonomous existence would not be firmly established. This is why it is usually futile for the examiner to try to coax a child of this age into cooperation. Firm, gentle mastery is more effective and more humane: the emerging personality is not required to lose face by yielding. Once the child has established independent existence, usually about the age of 3 years, he or she will become a friendly, amiable patient and will readily cooperate with all reasonable, nonthreatening requests.

Exploration of the environment and the interpersonal difficulties encountered with adults operate to make accident, trauma, and child abuse major health problems of this age group. Immunologic adaptations have also been changing. The young infant has certain passively acquired defenses against infectious disease that are lost toward the end of the first year. The effective replacement of this with artificial immunity and the supervision of the natural acquisition of disease resistance are major medical tasks. Until the newborn infant has lived with a recently acquired gut flora for a while, the enteric organisms are an important hazard. The child's inability to respond to certain antigens results in vulnerability to encapsulated bacteria of the respiratory tract for the first few years, creating a spectrum of disease unique to this time of life.

Acquiring the skills for independent function within the family is the task of the next 3 years. Such things as toilet training, self-dressing, and eating behavior are learned, and the difficulties encountered in this process are the common problems of life. Success in this phase is preparation for the next 10 years or so during which the task is to develop the capacity and skills necessary to function in our society. During these years society takes a leading role through its formalized training programs established for the young. Although the child is relatively free of acute disease, it is in these years that the slippage due to mental slowness, learning disability, chronic disease, and socioeconomic status begins to be manifest and to wreak its secondary tolls.

Adolescence

Adolescence, ushered in by the undeniable physiologic and anatomic changes of puberty, is characterized by accelerating growth rates of the mesenchymal and reproductive tissues. These changes occur in females about 2 years earlier

than in males. This growth spurt contains within itself, by endocrine feedback mechanisms, the seeds of its own termination. The wide range of normal developmental schedules requires great precision in descriptive terminology. To describe genitalia as "infantile" might be acceptable at an earlier age but will be entirely useless during this period when one normal 12-year-old may be "infantile" and another "well developed." Tanner (1965) has described a staging of development that correlates the events of sexual development with the growth-rate curve and makes possible a quick and accurate recording of an individual's status. The use of Tanner staging is now the standard for this purpose.

The first task of adolescence is acceptance of a new body and the gender role that accompanies it. For many, this is a difficult task, one that must be approached gradually. Unisex clothing and other strategies useful in delaying the decisions required by development will be seen. Girls will be ladies one day and tomboys the next. The quiet boy who has difficulty taking on "macho" ways will be distressed. Normal differences in breast and genital size, even though temporary, cause problems.

The second task is separation from home and family and establishing oneself as an independent adult in the society. This is just as important as separating from mother was at the age of 2 and can be equally unpleasant. It is difficult for parents to understand that by *being parents* they are disqualified as counselors for their own children, that there must be, at least symbolically, a revolution by which their child declares his or her independence, and that after this is accomplished, their relationship, however close, must be as adult to adult and not parent to child. The necessary separation does not come easy, and the child must seek a secure base outside the home; hence the importance of peer groups and the following of styles and fads and other means of allying with resources *outside* the home. The essence of these are that they must differ from those of the parent generation. Parents' efforts to join their adolescent children in these pursuits in ill-conceived attempts to be "buddies" are counterproductive. Unfortunately, this failure on the part of parents to understand normal development often leads the younger generation to adopt extreme tactics such as drug abuse, running away, or pregnancy to establish the point that must be made.

For females, the menarche is the best clinical sign that the patient has entered the last phase of declining rate of growth. Males will not enter this phase until 3 or 4 years later, and the event lacks such a clear clinical marker in their case. This cessation of growth marks a logical end of pediatrics, which by current convention is usually taken to be around age 18. For practical reasons, most pediatricians use high school graduation as a convenient marker, extending it in the case of patients suffering from marked developmental delay. This practice, of course, brings the pediatrician problems of gynecology, contraception, an occasional example of non-insulin-dependent diabetes mellitus (mature-onset diabetes of the young) and other problems more characteristic of adult practice.

Conclusion

Continual change is the essence of life. The cessation of growth at the end of adolescence is not the end of development. Development of physical prowess, skill, and mental processes continues for many years. Even middle age does not interrupt development. Inevitably a process of involution begins. Like growth in earlier years, it affects different tissues and structures at different rates, slowed at first by the replacement of declining functions with newfound skills and bionic parts. Ultimately, however, change ceases—life ceases.

And so it is that no two patients with the same diagnosis have the same disease. Their problem formulations will be different, and their appropriate managements cannot be the same.

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